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Contrasting Indian Ocean SST variability with and without ENSO influence: A coupled atmosphere-ocean GCM study

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With 10 Figures

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Summary

In this study, we perform experiments with a coupled atmosphere-ocean general circulation model (CGCM) to examine ENSO's influence on the interannual sea-surface temperature (SST) variability of the tropical Indian Ocean. The control experiment includes both the Indian and Pacific Oceans in the ocean model component of the CGCM (the Indo-Pacific Run). The anomaly experiment excludes ENSO's influence by including only the Indian Ocean while prescribing monthly-varying climatological SSTs for the Pacific Ocean (the Indian-Ocean Run). In the Indo-Pacific Run, an oscillatory mode of the Indian Ocean SST variability is identified by a multi-channel singular spectral analysis (MSSA). The oscillatory mode comprises two patterns that can be identified with the Indian Ocean Zonal Mode (IOZM) and a basin-wide warming/cooling mode respectively. In the model, the IOZM peaks about 3–5 months after ENSO reaches its maximum intensity. The basin mode peaks 8 months after the IOZM. The timing and associated SST patterns suggests that the IOZM is related to ENSO, and the basin-wide warming/cooling develops as a result of the decay of the IOZM spreading SST anomalies from western Indian Ocean to the eastern Indian Ocean. In contrast, in the Indian-Ocean Run, no oscillatory modes can be identified by the MSSA, even though the Indian Ocean SST variability is characterized by east–west SST contrast patterns similar to the IOZM. In both control and anomaly runs, IOZM-like SST variability appears to be associated with forcings from fluctuations of the Indian monsoon. Our modeling results suggest that the oscillatory feature of the IOZM is primarily forced by ENSO.

1. Introduction

The recent interests in the observed east–west contrast pattern in Indian Ocean sea-surface temperature (SST) anomalies have prompted the suggestion that the Indian Ocean has its own unstable coupled atmosphere-ocean mode like El Niño-Southern Oscillation (ENSO) (e.g., Saji et al, 1999; Webster et al, 1999). This interannual SST variability is often referred to as Indian Ocean Zonal Mode (IOZM) or Indian Ocean Dipole. The IOZM is characterized by opposite polarities of SST anomalies between the western and eastern parts of the equatorial Indian Ocean, and is accompanied with zonal wind anomalies in the central Indian Ocean. The strong wind-SST coupling associated with the IOZM has been used to argue for the similarity of the phenomenon to the delayed oscillator of ENSO (Webster et al, 1999). The fact that the temporal correlation between the observed IOZM and ENSO events is not strong and that several significant IOZM events have occurred in the absence of large ENSO events have lead to the suggestion that the IOZM is independent of ENSO (Saji et al, 1999). On the other hand, there are suggestions that the IOZM is not an